The Effect of Brexit on United Kingdom Productivity: Synthetic Control Analysis

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Abstract:

In this paper I analyze the effect of Brexit on United Kingdom labor productivity and its components using a synthetic control methodology. My results show that the Brexit vote had a negative impact on labor productivity, causing GDP per hour worked to decrease by an average of 2.24% per year in comparison to the absence of Brexit. The two components of labor productivity are GDP and hours worked. I find that the decrease in the GDP is more than the increase in hours worked per person, causing the labor productivity to decline.

Keywords: Brexit; labor productivity; productivity puzzle; synthetic control method.

JEL Classification: E24; E65; F13; O47.

Introduction

On the 23th of June 2016, 51.9% of the United Kingdom (UK) electorate voted to leave the European Union (EU), these results mean that the UK will enter into new trade and immigration arrangements with the EU. The UK can negotiate trade arrangements and immigration policies with the EU to stay in the single market, the custom union and provide easy access to European skilled labor, or fail to negotiate a trade arrangement and thus fall back to the World Trade Organization (WTO) terms with the EU and new immigration policies. The uncertainty associated with negotiating trade arrangements may affect the UK productivity and output through various channels. For example, companies may be discouraged from investing in productivity-boosting technology. Trade, FDI, skilled labor, and the movement of people between the UK and the EU will be reduced, leading to less innovation, less investment, less competition, less access to talent, and fewer economies of scale. Thus, this will disproportionately harm the productive, traded sectors of the economy (Dimson *et al*. 2016)

The UK formally signed the withdrawal agreement on the 31st of January 2020, but until the point of writing this paper, the UK has not agreed on any trade deal with the EU. Given that trading relationships between the UK and the EU member states have not changed yet at the time of writing this paper, I expect that any slowdown in the economic activities are due to expectations of the future uncertainty associated with the negotiation of a trade agreement in the UK economy

In this paper, I use synthetic control method of (Abadie, Diamond and Hainmueller 2010) in order to measure the causal effect of the Brexit vote on the UK's productivity by constructing a synthetic UK series that is not affected by the Brexit vote and analyze what the UK series will look like in the absence of the Brexit referendum and the vote to leave. The difference between the UK series and the synthetic UK series is the causal effect of the Brexit vote. The variables that I investigate are labor productivity (GDP per hour worked) and its components.

The rest of the paper is organized as follows: Section 1 provides literature review. Section 2 provides a detailed overview of the synthetic control method. Section 3 describes the data used. Section 4 provides the results and discussion. Section 5 assesses our validity of the results using permutation tests. Section 6 concludes.

1. Literature Review

The synthetic control method, used in this paper, has been used in the literature of assessing the impact of the Brexit vote on the UK's economy. Breinlich *et al.* (2020) found that the UK outward FDI increased by 17% and inward FDI decreased by 9% to and from the remaining 27 EU member states as firms and manufacturers shifted their operations from the UK to the remaining EU member states to benefit from the access of the single market.

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(Born *et al.* 2019) found that the Brexit vote caused a UK output loss of 1.7% to 2.5% by year end 2018. (Opatrny 2020) found that as a result of the leave vote, the 10-year UK bond yield increased by 1.2% and Real Effective Exchange Rate decreased by 10.8 index points. The results of these papers using the same methodology of synthetic control are consistent with my results that the UK is worse off following the results of the Brexit vote.

Additionally, (Gasiorek, Serwicka and Smith 2019) analyses the implications of Brexit on 122 manufacturing industries through investigating 5 different scenarios of trade arrangements ranging from hard to soft Brexit to find that all the 5 scenarios will have negative outcome impact on the UK manufacturing sector. Bloom *et al.* (2019) use survey approach of UK firms to identify the effects of the Brexit referendum. They also found that the Brexit referendum reduced the investment by 11% over the three years following the referendum. They found that the productivity dropped by 2 - 5% in the three years following the referendum, much of this is from a negative within-firm effect as top management commit number of hours per week on Brexit planning. Crafts and Mills (2020) found that by 2018, 10 years after the great recession, the UK productivity was 19.7% below the productivity growth trend. They attribute this underperforming to the great recession, waning impact of Information and Communication Technology (ICT) and the uncertainty about international trading following Brexit. That is to say, this paper is of particular importance as it will complement a growing literature about the UK productivity puzzle by investigating if the Brexit vote is contributing to slowdown in the UK productivity.

2. Methodology

The synthetic control method uses a weighted average of a set of potential control units to provide a synthetic control unit that closely resembles the affected unit in terms of predictors. In the context of the UK Brexit scenario, suppose that I have $J + 1$ units (here: country pairs) in periods $t = 1, 2, \dots, T$(here: years), where unit $j = 1$ is the treated unit (here: UK) and units $j = 2, \dots, J + 1$ are the untreated units used in the control group (here: OECD countries). Unit $j = 1$ is exposed to the intervention (here: outcome of the Brexit referendum) of at periods$T_0 + 1, \dots, T$ while being unaffected during the periods $t = 1, \dots, T_0$. In my analysis, I use 2016 as the period of intervention.Y_{it}^N is the outcome of unit i in the absence of intervention for units $i = 1, \dots, J + 1$. Y_{it}^I is the outcome of unit i at time t if the unit is exposed to intervention in periods $T_0 + 1, \dots, T$. The intervention has no impact on the pre-intervention periods. $Y_{it}^N = Y_{it}^I$ for $t = 1, \dots, T_0$. However, in practice, interventions may have an impact prior to their implementation (*e.g.,* via anticipation effects) (Abadie, Diamond and Hainmueller 2010). Y_N^{it}cannot be observed in the post-intervention periodt $= T_0 + 1, \dots, T$. Thus, it can best be modelled by a weighted average combination of untreated units in the donor pool.
The synthetic control can be represented by a $(J \times 1)$ vector of weights $W = (w_2, \dots, w_{j+1})W = (w_2, \dots, w_{j+1})$ where $0 \leq w_j \leq 1$for $j = 2, \dots J + 1$ and $w_2 + \dots + w_{j+1} = 1$.

The constructed synthetic control unit is $\widehat{Y}_{jt}^N$ is a weighted average of the untreated units of in the donor pool. One of the main assumptions of the synthetic control approach is that countries in the donor pool are not directly affected by the results of the Brexit referendum, nor any contemporaneous events. The choice of W is such that the characteristics of the treated unit are best resembled by the characteristics of the synthetic control.X_1 is a $(k \times 1)$ vector of pre-intervention characteristics of the treated unit X_0 is $(k \times j)$ matrix of the same characteristics of the donor pool. [2]The vector W^* is chosen to minimize the difference between the pre-intervention characteristics of the treated unit and the synthetic control unit $X_1 - X_0 W$. W^* is the value of W that minimizes $||X_1 - X_0 W||$ subject to the constraints of w_j mentioned above. According to (Abadie, Diamond and Hainmueller 2010). W^* is chosen to minimize the following equation

$$\sum_{m=1}^{k} v_m (X_{1m} - X_{0m} W)^2 \quad (1)$$

where: $v_m$is a weight that reflects the relative importance that is assigned to the mth variable when I measure the discrepancy between $X_1$and $X_0 W$. Typically, V is selected to weight the predictors in accordance to their predictive power on the outcome. If V is diagonal with main diagonal equal to $(v_1, \dots, v_k)$, then W^* is equal to the value of W for the above minimization. The constructed synthetic control unit is $\widehat{Y}_{jt}^N$ is a weighted average of the untreated units in the donor pool.

$$Y_{1t}^N = \sum_{j=2}^{J+1} w_j^* Y_{jt} \quad (2)$$

[2]See (Abadie, Diamond and Hainmueller 2010) for details about the calculation of the weight matrix.

Abadie, Diamond and Hainmueller (2010) show that if the weighted average of the synthetic control characteristics X_0 can match the treated unit characteristics X_1, it provides a valid counterfactual for Y_{jt}^N in the sense that $\widehat{Y}_{jt} - Y_{jt}^N$ is close to 0 in the pre-intervention period, $t = 1, \ldots, T_0$. For the post intervention period, where $t \geq T_0$ the treatment effect is the difference between the realized outcome and the synthetic control outcome.

$$Y_{1t} - \sum_{j=2}^{J+1} w_j Y_{jt} \quad (3)$$

Following (Harvey and Thiele 2017), I quantify the impact of Brexit using a set of pulse dummies and a step dummy. The set of pulse dummies $\lambda_j d_t^*$ show the intermediate impact of the intervention over the short run, while the step dummy variable λd_t models the long run impact or the average impact in the post intervention period, the long run impact takes effect after $m \geq 1$time periods. Denoting the synthetic control unit as $\widehat{Y}_{jt}^N$ then the intervention impact can be modelled as:

$$Y_{1t} - \widehat{Y}_{jt}^N = \mu_t^c + \lambda d_t + \sum_{j=1}^{m} \lambda_j d_t^* + \varepsilon_{0t} \quad (4)$$

$$d_t = \begin{cases} 0, & \text{for } t < T_0 + m \\ 1, & \text{for } t \geq T_0 + m \end{cases}$$

$$d_t^* = \begin{cases} 0, & \text{for } t \neq T_0 + j - 1 \\ 1, & \text{for } t = T_0 + j - 1, \end{cases} \qquad j = 1, \ldots, m$$

3. Data

The sample dataset used in the analysis includes 19 OECD countries, the sample spans from 1995 to 2019. All the data are with annual frequency and obtained from the OECD database. Description of each variable used are available in Table 1.

Table 1. Description of the economic variables used and their sources

Variable	Description	Source
GDP per hour worked	Annual total, 2010 = 100	OECD database
GDP	Annual GDP, expenditure approach, USD current prices fixed PPPs, annual levels	OECD Annual national accounts
Consumption	Annual private final consumption expenditures, volume	OECD Quarterly national accounts
Investment	Annual gross fixed capital formation, total, volume	OECD Quarterly national accounts
Exports	Annual exports of goods and services, national account basis, volume	OECD Quarterly national accounts
Imports	Annual imports of goods and services, national account basis, volume	OECD Quarterly national accounts
Employment	Annual total employment, labor force survey basis	OECD Quarterly national accounts
Population	Annual working age population, age 15-74	OECD Quarterly national accounts
Hours worked	Annual total hours per worker	OECD database
Labor productivity growth	Log difference between the GDP and the employment	OECD database
Inflation	Annual CPI annual growth rate	OECD database

4. Results and Discussion

4.1. Impact of Brexit Vote on Labor Productivity

Table 2 shows the weights assigned to each country in the donor pool to construct synthetic UK's productivity, where its constructed by a combination of USA, Finland, Norway, Italy, Netherlands and Portugal. Table 3 compares the pre-Brexit vote economic predictors of the UK to that of synthetic UK and weighted average of all countries in the donor pool. The results of Table 3 show that for the pre-Brexit period (1995 - 2015) on average for all the economic predictors, the synthetic UK provides much closer values to the UK compared to the values of the sample mean of all the countries in the donor pool

Table 2. Weights assigned to each country in the donor pool to construct synthetic UK

Country	Synthetic control weight	Country	Synthetic control weight
USA	32.3%	Finland	26.8%
Norway	23.0%	Italy	7.5%
Netherlands	2.4%	Portugal	1.8%
Austria	<1%	Australia	<1%
New Zealand	<1%	Luxembourg	<1%
Spain	<1%	Germany	<1%
Sweden	<1%	Hungary	<1%
Slovak	<1%	France	<1%
Japan	<1%	Korea	<1%
Czech	<1%		

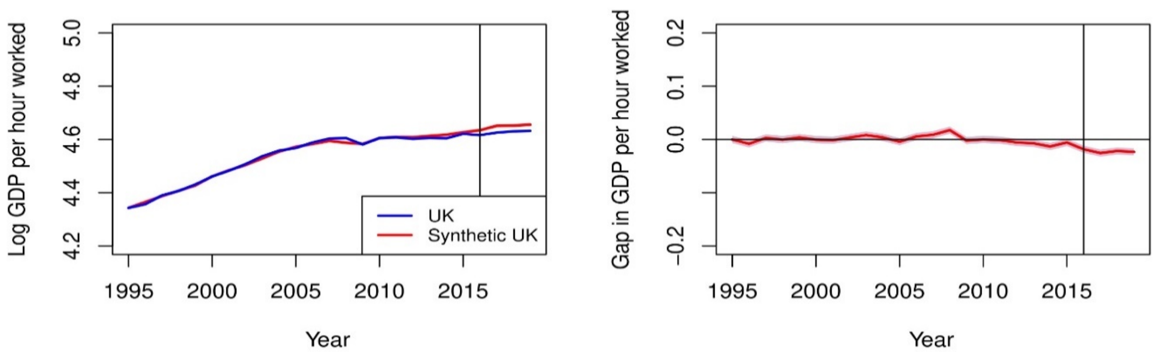
Table 3. GDP per hour worked economic predictors means before UK Brexit vote

Economic predictor	UK	Synthetic UK	Sample mean
Investment share of GDP	0.168	0.215	0.230
Log GDP	14.649	13.929	13.301
Imports share of GDP	0.253	0.268	0.396
Exports share of GDP	0.252	0.268	0.396
Labor productivity growth	28.106	28.222	27.848
Employment share	0.631	0.626	0.596
CPI	2.180	2.107	2.562
Log GDP (2011)	14.749	14.765	13.452
GDP per hour worked (2000)	4.461	4.461	4.603
GDP per hour worked (2012)	4.602	4.608	4.621
GDP per hour worked (2015)	4.621	4.627	4.651

Note: Column 2 reports X_1column 2 reports WX_0 and column 3 reports a simple average of all the countries in the donor pool.

Figure 1, left panel, shows a plot of the GDP per hour worked of the UK against the synthetic UK from 1995 to 2019. The plot shows that the UK and the synthetic UK GDP per hour worked both had the same trend over time, as the synthetic UK closely mimics the performance of the UK for the entire sample. However, following the Brexit vote, the UK series underperformed the synthetic UK series and the gap between the 2 series widened after 2016. Figure 1, right panel, shows a plot of the gap between the UK and the synthetic UK, following the Brexit vote, the gap between the UK and the synthetic UK widened and is negatively significant. The results show that at 68% confidence interval, the Brexit vote had a significant negative impact on the UK's productivity after mid-2016. The confidence interval bands are constructed as one standard deviation of the difference between the UK and synthetic UK in the pre-Brexit period. [3]

Figure 1. Log of annual GDP per hour worked for the UK and the synthetic UK



[3] The approach of Born *et al.* (2019) was followed in constructing the confidence interval as 1 standard error of the difference between the UK and synthetic UK in the pre-Brexit period.

Table 4. Estimation of equation 1

Variable	Coefficient	P-Value
λ_{2016}	-0.0186*** (0.002)	4.904e-09
λ_{2017}	-0.0257*** (0.002)	1.678e-11
λ_{2018}	-0.0218*** (0.002)	3.161e-10
λ_{2019}	-0.0235*** (0.002)	8.313e-11
λ (Average post Brexit impact)	0.02242*** (0.002)	1.599e-10

Note: The regression is estimated using Newey west HAC-SE to avoid the problem of serial correlation. The significance codes are 0.1* 0.05 significance, ** 0.01 significance, *** 0 significance.λ_{2016} takes a value of 1 in 2016 and 0 otherwise. λ_{2017} takes a value of 1 in2017 and 0 otherwise. λ_{2018} takes a value of 1 in 2018 and 0 otherwise. λ_{2019} takes a value of 1 in 2019 and 0 otherwise. λ is estimated in a separate regression without any pulse dummy variables, it takes a value of 1 in 2016, 2017, 2018 and 2019.

The results of equation 1, are in Table 4, show that due to the Brexit vote, the UK's labor productivity underperformed its synthetic counterpart by an average of 2.24% in the three years following the Brexit vote, where in the absence of the Brexit vote, the UK's labor productivity would have been on the same growth path as that of the synthetic UK.

4.2. Impact of Brexit vote on Gross Domestic Product

In assessing the impact of the Brexit vote on the UK's GDP, I construct the synthetic UK from a pool including 18 countries. Table 5 shows the weights assigned to each country in the donor pool. Synthetic UK GDP is best constructed mainly by a combination of USA, Italy, New Zealand, Luxembourg and Portugal, as they account for more than 93%, while the other countries have weights less than 1% each. Table 6 compares the pre-Brexit vote economic predictors of the UK to that of the synthetic UK and weighted average of all countries in the donor pool. The synthetic UK series economic predictors are matched closely to the UK series than the weighted average of the donor pool.

Table 5. Weights assigned to each country in the donor pool to construct synthetic UK

Country	Synthetic control weight	Country	Synthetic control weight
USA	48.0%	Italy	23.7%
New Zealand	19.6%	Luxembourg	7.2%
Portugal	1.4%	Netherlands	2.4%
Austria	<1%	Australia	<1%
Finland	<1%	Czech	<1%
Spain	<1%	Germany	<1%
Sweden	<1%	Hungary	<1%
Slovak	<1%	France	<1%
Japan	<1%	Korea	<1%

Table 6. GDP per hour worked economic predictors means before UK Brexit vote

Economic predictor	UK	Synthetic UK	Sample mean
Investment share of GDP	0.168	0.204	0.224
Log GDP (2011)	14.749	14.765	13.452
Imports share of GDP	0.253	0.277	0.402
Exports share of GDP	0.252	0.282	0.429
Labor productivity growth	28.106	28.389	27.797
Employment share	0.631	0.606	0.596
CPI	2.180	2.107	2.562

Note: Column 2 reports X_1 column 2 reports WX_0 and column 3 reports a simple average of all the countries in the donor pool

Figure 2, left panel, displays a plot of the UK's GDP against the synthetic UK GDP from 1995 to 2019. The plot shows that the UK and the synthetic UK series are both on the same trend for the entire sample, following the Brexit vote the UK GDP series underperformed the synthetic UK. Figure 2, right panel, shows the gap between the

UK series and the synthetic UK series, where the gap between the UK and its synthetic counterpart widened following the Brexit vote and on a downward trend. The deviation between the two series is statistically significant. (Born *et al. 2019)*, who constructed the UK GDP series using quarterly real GDP found similar results to mine that the UK underperformed the synthetic UK.[4] In monetary terms, Table 7 below shows that the cumulative of loss for the UK GDP between 2016 to 2019 is almost 133.3 billion dollars, and Table 8 shows the estimation of the step and pulse dummy variables of the regression of equation 1.

Table 7. Brexit impact on GDP

Variable	GDP impact in Millions
2016	-2,346
2017	-18,209
2018	-51,238
2019	-63,896

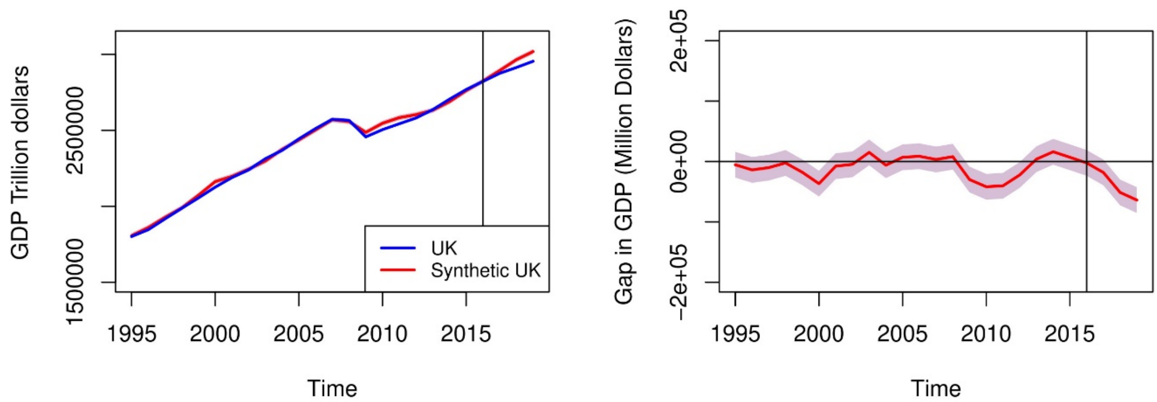
The impact of the Brexit vote calculated as the difference between the UK and Synthetic UK series in the post-Brexit period.

Table 8. Estimation of equation 1

Variable	Coefficient	P-Value
λ_{2016}	0.002816 (0.002)	0.2033
λ_{2017}	-0.002667 (0.002)	0.2273
λ_{2018}	-0.0138*** (0.002)	2.794e-06
λ_{2019}	-0.0177481*** (0.002)	6.692e-08
λ (Average post Brexit impact)	-0.0078464 (0.005)	0.1474

Note: The regression is estimated using Newey west HAC-SE to avoid the problem of serial correlation. The significance codes are 0.1, * 0.05 significance, ** 0.01 significance, *** 0 significance.λ_{2016} takes a value of 1 in 2016 and 0 otherwise. λ_{2017} takes a value of 1 in2017 and 0 otherwise. λ_{2018} takes a value of 1 in 2018 and 0 otherwise. λ_{2019} takes a value of 1 in 2019 and 0 otherwise. $\lambda$is estimated in a separate regression without any pulse dummy variables, it takes a value of 1 in 2016, 2017, 2018 and 2019.

Figure 2. Log of annual real GDP for the UK and the synthetic UK



4.3. Impact of Brexit vote on Labor Input

Labor input, measured as the labor hours worked, is defined as the total number of hours actually worked per person, effectively used in production.[5] In assessing the impact of Brexit vote on the labor input in the UK, I construct the synthetic UK based on a combination of all the countries in the donor pool.

[4] Born *et al.* (2019) found that by end of 2018, the GDP loss accounted for £55billion.

[5] Hours actually worked reflect regular hours worked by full-time and part-time workers, paid and unpaid overtime hours worked in additional jobs, excluding hours not worked because of public holidays, annual paid leaves, strikes and labor disputes, bad weather, and economic conditions.

Table 8 shows the weights assigned to each country in the donor pool to construct synthetic UK labor hours worked, the UK labor input is constructed as a combination of mainly Netherlands, USA and Germany, while most of the countries in the donor pool have weights less than 1% each.

Table 9 shows that the pre-Brexit vote predictors of the UK are closely matched by the synthetic UK series compared to weighted average of all the countries in the donor pool. Hence, the combination of the synthetic UK series made up of 18 countries is best used to mimic the performance of the UK series than any other weighted average.

Figure 3 shows a plot of the UK labor hours worked against that of the synthetic UK. Although the UK number of hours worked started to decrease following the Brexit vote, the synthetic UK was on a steady trend for the whole entire period and the UK series was above it, but the gap between the two series narrowed following the Brexit vote. Figure 3, right panel, displays that in the post-Brexit period, the gap in the number of hours worked between the UK and its synthetic counterpart narrowed.

Table 8. Weights assigned to each country in the donor pool to construct synthetic UK

Country	Synthetic control weight	Country	Synthetic control weight
Netherlands	58.5%	USA	29.7%
Germany	7.7%	Luxembourg	<1%
Portugal	<1%	Italy	<1%
Austria	<1%	Australia	<1%
Finland	<1%	Czech	<1%
Spain	<1%	New Zealand	<1%
Sweden	<1%	Hungary	<1%
Slovak	<1%	France	<1%
Japan	<1%	Korea	<1%

Table 9. GDP per hour worked economic predictors means before UK Brexit vote

Economic predictor	UK	Synthetic UK	Sample mean
Investment share of GDP	0.168	0.203	0.225
Log GDP	14.649	14.490	13.324
Labor productivity growth	28.106	28.146	27.818
Employment share	0.631	0.631	0.604
CPI	2.180	2.156	2.435
Log labor hours worked	7.315	7.332	7.401

Note: Column 2 reports X_1 column 2 reports WX_0 and column 3 reports a simple average of all the countries in the donor pool

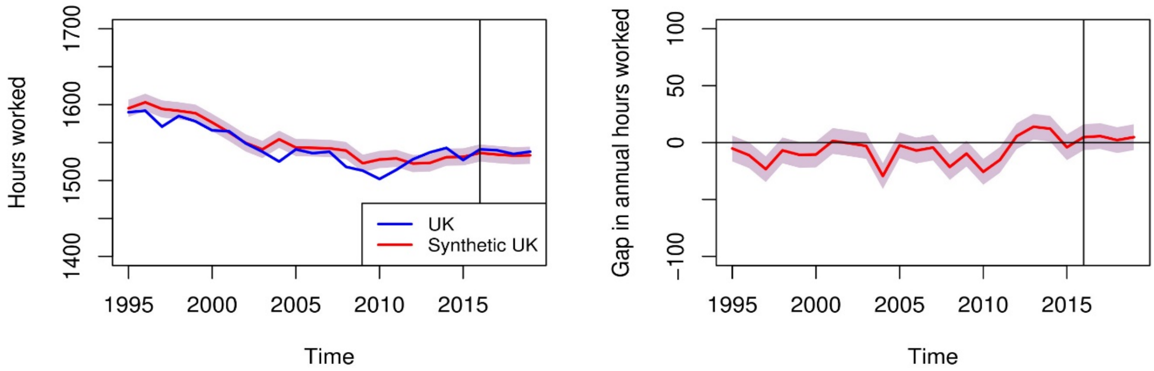
Table 10 shows the regression estimation of equation 1, the results show that although the coefficients of the dummy variables are positive and significant, they decreased significantly between 2017 and 2018 before it increased again in 2019 but still below that of 2017 to explain the negative impact on the number of hours worked in the UK.

Table 10. Estimation of equation 1

Variable	Coefficient	P-Value
λ_{2016}	0.00791*** (0.002)	0.0079071
λ_{2017}	-0.00853*** (0.002)	0.0085328
λ_{2018}	-0.00624** (0.002)	0.0062414
λ_{2019}	-0.00792*** (0.002)	0.0079218
λ (Average post Brexit impact)	-0.00765*** (0.005)	0.000479

Note: The regression is estimated using Newey west HAC-SE to avoid the problem of serial correlation. The significance codes are:0.1 ,* 0.05 significance, ** 0.01 significance, *** 0 significance.λ_{2016} takes a value of 1 in 2016 and 0 otherwise. λ_{2017} takes a value of 1 in2017 and 0 otherwise. λ_{2018} takes a value of 1 in 2018 and 0 otherwise. λ_{2019} takes a value of 1 in 2019 and 0 otherwise. λ is estimated in a separate regression without any pulse dummy variables, it takes a value of 1 in 2016, 2017, 2018 and 2019.

Figure 3. Annual hours worked for the UK and the synthetic UK



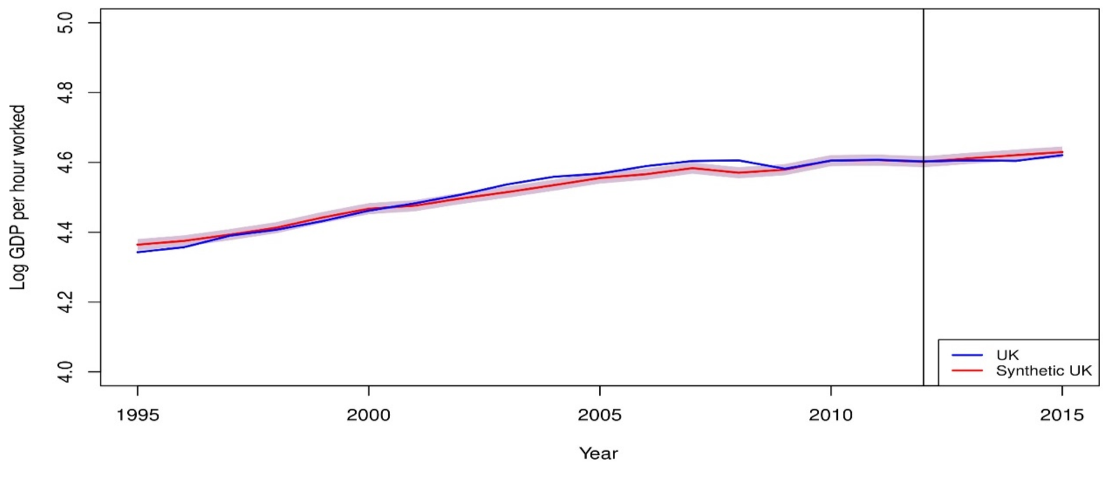
5. Permutation Tests

In order to evaluate the credibility of my results that the UK labor productivity was affected due to the Brexit vote, I perform two permutation tests. In-time permutation test and leave one out permutation test.

5.1. In-time Permutation Test

I assign the Brexit to a different year, 2012, instead of 2016. I use the same predictors of Table 3 and still finding that the synthetic UK series is closely matched to the UK series than the weighted average of all the countries in the donor pool. Figure 4 displays the results of the in-time permutation test. The results show that the synthetic UK GDP per hour worked almost reproduces the evolution of the UK GDP per hour worked between 1995 and 2012. After the hypothetical 2012 Brexit assigned, the UK and the synthetic UK do not diverge significantly and considerably from each other between 2012 and 2015, the small divergence was already present in the data as in Figure 1. Therefore, I can conclude that the widening of the divergence following 2016 in figure 1 is the casual effect of the Brexit vote on the UK GDP per hour worked.

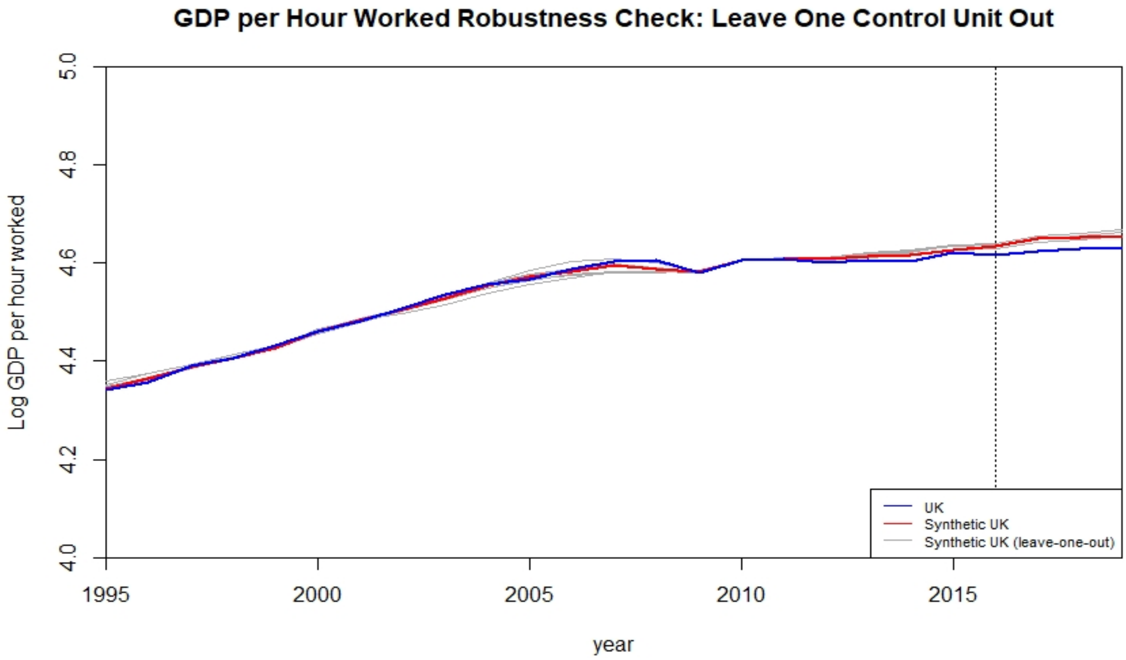
Figure 4. In-time permutation test for the UK and the synthetic UK



5.2. Robustness Check

As the GDP per hour worked is constructed as a weighted average of the six countries USA, Finland, Portugal, Norway, Italy and Netherlands. I run a robustness check to test the sensitivity of my results, in terms of the pre-Brexit fit to changes in weights assigned to each country in the donor pool, I do so by re-estimating the synthetic UK five times each time by omitting one of the countries in the donor pool. Figure 5 displays the UK, synthetic UK and the re-estimated synthetic UK when omitting one of the countries in the donor pool. The results show that the synthetic UK constructed in Figure 1 by the combination of the six countries is robust to the exclusion of any particular country from the donor pool.

Figure 5. In-time permutation test for the UK and the synthetic UK



5.3. Balanced Growth Test

Harvey and Thiele (2017) suggest that the target and its synthetic counterpart should be co integrated during the pre-intervention period, by using KPSS balanced growth co-integration test on the contrast between the target and its synthetic counterpart to test if both series are on the same growth path in the pre intervention period. If the null hypothesis of stationarity is not rejected, then the UK and its synthetic counterpart are on the same growth path, thus co integrated over the pre-Brexit period. The results of Table 11 below show that the contrast between the UK and synthetic UK GDP per hour worked is stationary. Therefore, both series had the same growth path in the pre-Brexit period.

Table 11. Balanced growth test.

KPSS level	Critical value (10%)
0.21002	0.347

Note: KPSS (2) balanced growth test for the contrast between the UK and synthetic UK GDP per hour worked in the pre-Brexit period

Conclusion

In this paper I examined the impact of the Brexit vote on the labor productivity of the UK. By using synthetic control method, I identify the effect of the Brexit vote by constructing synthetic UK series to compare it to the actual UK series. My estimates found three key impacts the Brexit vote caused to the UK economy.

Firstly, in comparison to its synthetic counterpart, the UK's labor productivity under performed by an average of 2.24% per year over the three years following the Brexit vote, which reflects the uncertainty in the UK investment and labor markets associated with leaving the EU without a trade deal.

Secondly, the UK Real GDP had a cumulative loss of 133.3 billion dollars between 2016 to 2019. Lastly, I found that average annual hours worked per person are 2.16 and 4.17 hours more in 2018 and 2019 than the synthetic UK. As the labor productivity is constructed by the GDP and the labor hours worked, the decrease in the GDP is more than the slight increase in the labor hours worked, thus the labor productivity was negatively affected.

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